Sleep Health: Journal of the National Sleep Foundation 11 (2025) 198–205

Contents lists available at ScienceDirect

Sleep Health: Journal of the National Sleep Foundation

journal homepage: www.sleephealthjournal.org

Sleep on it: A pilot study exploring the impact of sexual activity on sleep outcomes in cohabiting couples

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ARTICLE INFO

Article history:
Received 16 July 2024
Received in revised form 13 October 2024
Accepted 15 November 2024

Keywords:
Bedtime
Orgasm
Masturbation
Behavior
Sex
Intercourse

ABSTRACT

Objective: The main aim of this pilot study was to examine the impact of sexual activity on objective and subjective sleep parameters.
Methods: A repeated-measures counterbalanced, cross-over design with three conditions - no sex, solo masturbation, and partnered sex was employed with cohabiting couples. In this pilot study 14 individuals participated in the study (7 females, 7 males; mean age 29.9 ± 3.4 years). Sexual activities and sleep were monitored for 11 consecutive nights using a portable polysomnography system (*DREEM3*) and daily sex and sleep surveys.
Statistical analyses: Linear mixed models were employed to examine differences in sleep, readiness, and motivation following three conditions (i.e., no sex, solo masturbation, and partnered sex). Cohen's d effect sizes with 95% confidence limits were also calculated for pairwise comparisons between conditions with the effect of magnitude interpreted as follows: small = 0.2, medium 0.5, large 0.8, very large 1.0. Wilcoxon Signed-Rank tests were conducted to compare the sleep stage concordance between partners across conditions.
Results: Participants attempted sleep considerably later following the solo masturbation and partnered sex conditions compared to the no sex condition ($p = .004$). Wake after sleep onset and sleep efficiency improved considerably following solo masturbation and partnered sex compared to no sex ($p < .05$). No differences were observed across conditions for subjective sleep ($p > .05$). Sleep stage concordance for rapid eye movement sleep was longer when participants slept together regardless of whether they engaged or did not engage in sexual activity ($p < .05$).
Conclusions: Engaging in sexual activity, whether solo masturbation or partnered, significantly enhanced objective sleep quality by reducing wakefulness after sleep onset and improving sleep efficiency. Objective wake up time, sleep duration, sleep latency and subjective sleep measures showed no differences post-sexual activity, potentially attributable to the small sample size and the inclusion of only healthy sleepers. Future research should focus on expanding the sample size and incorporating participants with sleep disorders to thoroughly investigate if sexual activity before bedtime can improve sleep.
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Introduction

It is widely recognized that sexual behavior, particularly an orgasm, has a soporific effect on subsequent sleep.[1-3] The exact mechanisms behind the soporific effect following an orgasm are not clear, yet the combined release of oxytocin, prolactin, and the inhibition of cortisol is reported to have relaxing properties.[4-6] Oxytocin, often referred to as the bonding hormone is elevated following sexual intercourse.[7] This hormone has been associated with a higher quality of life, lower levels of cortisol (stress hormone) and improved

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https://doi.org/10.1016/j.sleh.2024.11.004
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quality of sleep in males and females.[8,9] Prolactin, often associated with the quality of orgasm and sexual satisfaction, has been shown to increase following orgasm, and even more so, when orgasm occurs during sexual intercourse.[10,11] Despite anecdotal evidence suggesting that sexual activities that involve an orgasm may enhance subsequent sleep,[1-3] these data are limited to subjective sleep reports. While there are limited data on the objective sleep behavior following sexual activity, one comparable area of interest relates to sleep stage concordance whereby studies investigate the level of synchronisation between individuals who cosleep.[12,13] Studies have shown that partners who cosleep tend to have large agreement across sleep stages, particularly during rapid eye movement (REM) sleep.[12,13] To our knowledge, no study has explored how sexual activity with a partner impacts the synchronisation of sleep stages.

A large cross-sectional population-based survey examining the perceived influence of sexual behavior on subjective sleep variables indicated that both masturbation and intercourse that involved an orgasm reduced sleep latency and improved sleep quality.[3] Sexual activity without an orgasm was perceived to have a negative impact on subsequent sleep.[3] Similar observations were made by Oesterling et al[2] who employed a subjective sleep and sex diary-based design for 14 consecutive nights to examine the relationship between sexual activity (sexual intercourse and masturbation with or without orgasm) on subjective sleep latency and sleep quality. Consistent with previous cross-sectional data,[1,3] both men and women reported that sexual intercourse and masturbation with an orgasm shortened sleep latency and improved sleep quality.

The only investigation to objectively examine sleep in humans (e.g., using polysomnography) following sexual activity with and without orgasm was conducted over 35 years ago.[14] No differences in nocturnal sleep across three conditions (i.e., 15 minutes of light reading, masturbation without orgasm, and masturbation with orgasm) were found.[14] Some significant limitations associated with the experimental design may have influenced the findings. For example, the control condition of reading in bed for 15 minutes before attempting sleep may have sleep inducing effects.[15] The experiment was conducted in a laboratory which may elicit varying responses on sleep.[16] Further, the results were limited to solo masturbation such that the findings may not be appliable to the potential sleep benefits of sexual activity with a partner. Apart from potential sleep benefits of sexual activity with or without a partner, it has also been shown to enhance psychological well-being, vigor and mood.[17-20] Our study aims to address this gap by capturing data on mood, motivation, and readiness for the next day's activities.

To address the limited evidence pertaining to sleep following sexual activity, the main aim of the present study was to examine the impact of sexual activity (e.g., no sex, solo masturbation, partnered sex) on objective and subjective sleep. Based on the existing evidence indicating that sleep improves following sexual activity, it was hypothesized that couples that engaged in one of the sex conditions (i.e., partnered sex or solo masturbation) would experience favorable (i.e., improved) sleep outcomes. Further to this, the present study aims to examine how sexual activity with a partner impacts the synchronisation of sleep stages. A secondary hypothesis was that sexual activity would improve an individuals' motivation and readiness for the next day.

Methods

Participants

Fourteen participants aged 18 years and over (7 heterosexual couples; 7 females, mean age, 26.4 ± 2.1 years; height 168.7 ± 7.4 cm; weight 63.4 ± 6.1, 7 males; mean age, 26.5 ± 2.8 years; height 188.0 ± 7.6 cm; weight 88.5 ± 17.1) participated in the study. Following advertisements on the social media platform, Facebook, participants registered their interest to participate in the study. All potential participants received a prescreening questionnaire via Qualtrics (Provo, UT, 2014) requesting basic demographic information to determine their eligibility. The inclusion criteria required participants to be actively living together in South Australia, not pregnant, or have children, and engage in sexual activity more than once a week. Participants were asked in the prescreening questionnaire whether they had been diagnosed with a sleep disorder. If they answered "yes," they were excluded from the study. Ethical approval was obtained through the University Human Research Ethics Committee (H16/09-260). All participants gave written informed consent.

Procedure

The study was carried out between August 2022 and August 2023. A total of 221 participants registered initial interest to participate in the study. Eighty-nine potential participants did not provide any contact information to progress through the initial recruitment process. Among the 132 respondents who did proceed, several exclusion criteria were applied: 58 were excluded for having children, 25 for residing outside of South Australia, 12 for a diagnosed sleep disorder, 10 for reporting sexual activity of once or less per week, and 3 for being pregnant. This left 24 eligible participants, who were then sent a prestudy survey via Qualtrics (Qualtrics, Provo, UT) to collect basic demographic information and confirm that they were part of a couple living together and willing to participate in the study. Of these, 10 were excluded because they were not cohabitating or chose to withdraw, resulting in 14 participants who met all criteria and completed the study. Following initial screening and recruitment, participants attended a one-to-one information session with the lead researcher to discuss in detail the experimental protocol, and the operation of the *DREEM3* (Beacon Biosignals Inc; Boston, MA) headband and associated software.

Following the one-on-one information session, participants were monitored for a total of 11 nights using a repeated-measures, counterbalanced, crossover design. This design ensured that sexual activity conditions (no sex, solo masturbation, and partnered sex) were distributed across both weekdays and weekends to account for any variability in sleep associated with different days of the week (see Fig. 1). During the data collection period, participants completed a self-report sex and sleep diary, and objective measures of sleep were collected. During the no sex condition, couples were asked to participate in their usual presleep behaviors with no sexual activity. During the solo masturbation and partnered sex conditions, participants were instructed to participate in the sexual activity as the last behavior they perform prior to attempting to go to sleep. To avoid a delay in sleep onset latency following an orgasm in the solo masturbation condition, participants were instructed to perform this behavior and sleep in a separate room to their partner.[2] This was also decided due to the practical execution and variability of time required to achieve an orgasm via the solo masturbation method.[21] Participants were instructed to place and connect their *DREEM3* headbands upon completion of their sexual activity (i.e., partnered sex, or solo masturbation), or immediately prior to sleep when no sexual activity was engaged in. Participants were instructed to go to bed and wake up as per their normal routines. Each morning participants were asked to place their *DREEM3* headbands on charge to enable the data transfer to the server and complete their daily sex and sleep diary questionnaire. Diaries were completed the following morning to avoid any impacts on sleep.

Measures

Online subjective sex and sleep diary

Sexual activities. Participants recorded subjective assessments of their sexual activities including the time of day they started

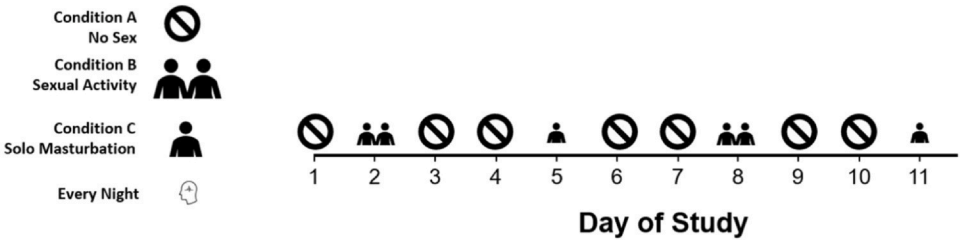

Fig. 1. A schematic representation of the experimental protocol for a couple. Note. Using a repeated-measures counterbalanced, cross-over design each couple completed two partnered sex nights and two solo masturbation nights

Table 1
Sleep data derived from *DREEM3* headband

Sleep data	Description
Sleep onset latency (min)	Period between bedtime and the first two epochs of sleep
Sleep duration (h)	Total amount of time in bed spent in any stage of sleep
Sleep efficiency (%)	Percentage of time in bed spent in any stage of sleep
Wake after sleep onset (WASO, min)	Amount of time spent awake after sleep onset
Stage 1 sleep (N1, %)	Percentage of sleep duration that is stage 1 sleep
Stage 2 sleep (N2, %)	Percentage of sleep duration that is stage 2 sleep
Slow wave sleep (N3, %)	Percentage of sleep duration that is stage 3 sleep
Rapid eye movement sleep (REM, %)	Percentage of sleep duration that is REM sleep
Duration of stage 1 sleep (N1, min)	Total duration of time spent in stage 1 sleep
Duration of stage 2 sleep (N2, min)	Total duration of time spent in stage 2 sleep
Duration of slow wave sleep (N3, min)	Total duration of time spent in stage 3 sleep
Duration of rapid eye movement sleep (REM, min)	Total duration of time spent in REM sleep

REM, rapid eye movement; WASO, wake after sleep onset.

engaging in the activity (i.e., solo masturbation, partnered sex), the duration of the activity, whether an orgasm was achieved, and the perception of the orgasm intensity on a 100-point visual analog scale where 0 = "*absence of orgasm*" and 100 = "*maximum orgasm intensity*."[22]

Readiness and motivation. Participants recorded their readiness and motivation for the upcoming day on a 100-point visual analog scale where readiness was anchored with 0 = "*not at all ready*" and 100 = "*extremely ready*" and motivated was anchored with 0 = "*not at all motivated*" and 100 = "*extremely motivated*."

Sleep. Participants recorded subjective assessments of their sleep behavior for the duration of the study using an online daily sleep diary. Participants were asked to record the start and end date/time of all nocturnal sleep periods via Qualtrics. Participants were asked to record their perceived sleep onset latency in minutes, and sleep quality on a 100-point visual analog scale, where 0 = "*poor*" and 100 = "*excellent*."[23] Participants were asked to record their sleep behavior as soon as practicable after waking to encourage accurate recall.

Portable polysomnography

The *DREEM3* headband was used for at-home polysomnographic measurement of sleep during the study period. The DREEM3 is wireless and worn during sleep. The device records, stores, and automatically analyses physiological sleep data. Following the recording, the *DREEM3* connects to a mobile device via Bluetooth to transfer aggregated metrics to a dedicated mobile application and transfer raw data to the host server. The *DREEM3* headband contains three types of embedded sensors: (1) Five electroencephalogram dry electrodes yielding seven derivations (FpZ-O1, FpZ-O2, FpZ-F7, F8-F7, F7-O1, F8-O2, FpZ-F8; 250 Hz with a 0.4-35 Hz bandpass filter) to collect brain cortical activity data, (2) a 3D accelerometer located over the head which records movements, position, and breathing frequency, and (3) red-infrared pulse oximeter located in the frontal band. The *DREEM3* headband is composed of foam and fabric with an elastic band behind the head making it adjustable such that it is tight enough to be secure, but loose enough to minimize discomfort.[24] Sleep data derived from the *DREEM3* headband are presented in Table 1.

Statistical analysis

All data were reported as mean ± standard deviation. Descriptive analyses were conducted for all sleep variables. Normality was confirmed using the Shapiro-Wilk test and visual inspection of Q-Q plots for all sleep variables. There were two nights in which participants did not record an orgasm; these data were excluded from all analyses. Separate linear mixed models were conducted to determine the impact of sex condition on each sleep-based outcome measure. The effect of sex condition (i.e., no sex, solo masturbation, partnered sex) on each dependent variable was examined using linear mixed models, with sex condition and gender specified as a fixed effect and participant as well as couple entered as a random intercept terms. These nested random effects accounted for individual differences, as well as covariation between partners' sleep outcomes. Where a significant main effect was observed, post hoc comparisons with Bonferroni corrections were conducted to compare each sex condition (i.e., no sex, solo masturbation, partnered sex) between groups. Cohen's d effect sizes with 95% confidence limits were also calculated for pairwise comparisons between conditions with the effect of magnitude interpreted as follows: small = 0.2, medium 0.5, large 0.8, very large 1.0[25] (see Supplementary Material: Table 4 and Table 5).

To explore how sexual activity with a partner impacts the synchronization of sleep stages, sleep stage concordance was calculated by examining the sleep stage overlap between couples based on total time spent in each sleep stage.[12] Data were structured such that each row representing a specific sleep stage (i.e., N1, N2, N3, REM) and columns indicating the total time spent in each sleep stage. To calculate the overlapping time spent in each sleep stage, the minimum time spent in that stage by both partners was determined. Subsequently, the total overlapping times across all sleep stages was computed and the percentage overlap was then calculated using the following formula.

Percentage Overlap Calucation

$$= \left(\frac{\text{total overlapping time}}{\text{total time PartnerA} + \text{total time PartnerB}} \right)^{*}100$$

Taking into consideration the small sample size, separate Wilcoxon Signed-Rank tests were conducted to compare the sleep stage concordance between partners across conditions (solo masturbation, sleeping alone and partnered sex, sleeping together, or no sexual activity and sleeping together).[26] Statistical significance for all analyses were set at $p < .05$. All data were analyzed using IBM SPSS Statistics (v24.0; IBM Corp., Armonk, NY).

Results

Descriptive statistics

On average, participants reported engaging in solo masturbation for 19.3 ± 12.4 minutes compared to 33.3 ± 18.5 minutes in the partnered sex condition. Descriptive statistics exploring the gender differences are presented in Fig. 2.

Sleep

All participants complied with the study protocol. Overall, participants attempted sleep later, spent less time awake throughout the night, had a higher sleep efficiency, and felt more ready and motivated the following day when they engaged in sexual activity with a partner the night prior compared to when they did not engage in sexual activity with their partner (Table 2). Linear mixed models revealed a significant main effect of sex condition (no sex, solo masturbation and sex with a partner) on bedtime ($F_{2136.4} = 5.73$, $p = .004$), wake after sleep onset (WASO) ($F_{2131.9} = 8.28$, $p < .001$), and sleep efficiency ($F_{2133.0} = 5.75$, $p = .004$). There were no significant differences between sex condition for wake-up time, sleep latency, total sleep time, or subjective sleep quality (Table 2).

The average intensity of the orgasms reported was 74 ± 14 on the orgasm intensity scale. Correlations revealed significant correlations between orgasm intensity and subjective sleep quality, readiness and motivation for the next day (see Supplementary Material: Table 6). Post-hoc comparisons revealed participants attempted sleep significantly later following the solo masturbation condition (23:30 ± 01:15) than the no sex condition (22:55 ± 01:08, $p = .007$). Participants spent more time awake after sleep onset in the no sex condition (22.9 ± 14.6 minutes) compared to both the solo masturbation (16.2 ± 9.9 minutes, $p = .019$) and sex with a partner condition (16.3 ± 9.8 minutes, $p = .002$). Participants also had lower sleep efficiency following the no sex condition (91.5% ± 4.0%) compared to the sex with a partner condition (93.4% ± 3.0%, $p = .012$).

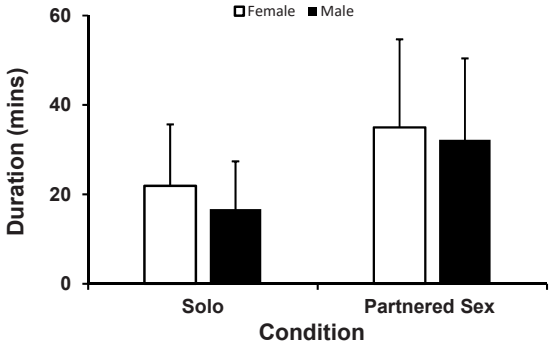

Fig. 2. Descriptive statistics exploring sexual activity duration (minutes) between males and females between the solo masturbation and partnered sex condition

Sleep stages

Table 3 shows both the percentage of sleep stages and duration within each stage according to sex condition and gender. Linear mixed models revealed a significant main effect of sex condition (no sex, solo masturbation, and sex with a partner) on N1 duration ($F_{2132.3} = 4.22$, $p = .0168$). Post-hoc comparisons revealed participants spent more time in N1 following the no sex condition (27.9 ± 8.8) compared to the solo masturbation condition (25.8 ± 4.5, $p = .04$). Separate Wilcoxon Signed-Rank tests were conducted to compare the sleep stage concordance between partners across conditions (solo masturbation, sleeping alone and partnered sex, sleeping together, or no sexual activity and sleeping together). There was a significant difference for REM sleep between solo masturbation, sleeping alone and no sexual activity, sleeping together ($W = 27$, $p = .031$, $r = 0.8$). There was also a significant difference for REM sleep between solo masturbation, sleeping alone and partnered sex, sleeping together ($W = 26$, $p = .047$, $r = 0.8$). These data indicate that sleep stage concordance for REM sleep was longer when participants slept together regardless of whether they engaged in sexual activity or did not engage in sexual activity. There were no other statistical differences for any other sleep stage concordance scores across conditions ($p > .05$).

Readiness and motivation

Linear mixed models revealed a significant main effect of sex condition (no sex, solo masturbation and sex with a partner) for readiness for the upcoming day ($F_{2130.0} = 4.33$, $p = .0151$), and for motivation for the day ($F_{2128.80} = 5.69$, $p = .004$). Post-hoc comparisons revealed participants felt more ready for the day following the sex with a partner condition (76.6 ± 14.2) compared to the no sex condition (67.1 ± 15.8, $p = .019$). Post-hoc comparisons revealed participants felt more motivated for the day following the sex with a partner condition (75.8 ± 11.8) compared to the no sex condition (64.7 ± 17.0, $p = .016$).

Discussion

The main aims of the present study were to (1) examine the impact sexual activity on subsequent sleep behavior; (2) examine how sexual activity with a partner impacts the synchronisation of sleep stages and (3) examine the impact sexual activity on motivation and readiness for the next day. Objectively measured WASO and sleep efficiency improved following solo masturbation and partnered sex compared to no sexual activity. These findings suggest that sleep quality (i.e., WASO and sleep efficiency) appears to improve following sexual activity. These improvements may be associated with the hormonal (e.g., changes to oxytocin, prolactin, or cortisol[4-6]) or psychological effects (e.g., mood changes[27] of sexual activity and/or orgasm). Sleep stage concordance for REM sleep was longer when participants slept together regardless of whether they engaged or did not engage in sexual activity. There were no other statistical differences for any other sleep stage when exploring sleep stage concordance. There was more time spent in N1 (i.e., the lightest stage of sleep) in the no sex condition compared to the solo masturbation condition. Despite not observing any significant differences for the other sleep variables between the no sex, solo masturbation, and partnered sex conditions, there were strong effect sizes for sleep duration and WASO such that participants slept longer and spent less time awake throughout the night following sexual activity with a partner. There were moderate to large effects between genders where women slept longer and spent less time awake throughout the night following both solo masturbation and sexual activity with a partner conditions.

Table 2
Sleep/wake behavior as a function of condition (no sex, solo masturbation, partnered sex)

Characteristic	Sex condition			Statistical outcomes
	No sex (Mean ± SD) N = 88	Solo masturbation (Mean ± SD) N = 30	Partnered sex (Mean ± SD) N = 33	
Bedtime (hh:mm)[#]	22:55 ± 01:08[a]	23:30 ± 01:15[a]	23:21 ± 01:08	*F*(2136.4) = 5.73, *p* = .00409
Female	23:01 ± 01:01[a]	23:41 ± 01:08[a]	23:24 ± 01:12	
Male	22:53 ± 01:14	23:18 ± 01:20	23:19 ± 01:07	
Wake-up time (hh:mm)	06:56 ± 01:08	06:54 ± 01:16	07:22 ± 01:26	*F*(2134.9) = 0.64, *p* = .53
Female[#]	07:04 ± 01:08	06:59 ± 01:16	07:36 ± 1:34	
Male	06:48 ± 01:08	06:50 ± 01:19	06:59 ± 1:19	
Sleep latency (min)	16.9 ± 13.2	13.0 ± 10.8	13.3 ± 7.9	*F*(2132.1) = 1.68, *p* = .191
Female	16.5 ± 12.7	12.9 ± 9.8	13.9 ± 6.9	
Male	17.3 ± 13.8	13.0 ± 12.1	13.0 ± 8.5	
Subjective sleep latency (min)	19.4 ± 19.8	14.2 ± 9.5	13.7 ± 8.9	*F*(2133.9) = 1.23, *p* = .295
Female	17.9 ± 11.9	14.7 ± 9.6	18.4 ± 13.4	
Male	15.8 ± 9.2	13.7 ± 9.7	13.7 ± 8.9	
Total sleep time (h)	7.3 ± 1.1	6.9 ± 0.8	7.4 ± 0.9	*F*(2133) = 1.84, *p* = .163
Female	7.4 ± 1.1	6.8 ± 0.7	7.8 ± 0.4	
Male	7.1 ± 1.1	6.9 ± 0.9	7.2 ± 0.6	
Wake duration (WASO; min)[#]	22.9 ± 14.6[a,b]	16.2 ± 9.9[a]	16.3 ± 9.8[b]	*F*(2131.9) = 8.28, *p* = .00041
Female[#]	20.4 ± 9.4[a,b]	13.5 ± 7.4[a]	12.5 ± 4.5[b]	
Male[#]	25.0 ± 17.6	19.1 ± 11.5	18.3 ± 11.3	
Sleep efficiency (%)[#]	91.5 ± 4.0[a,b]	93.2 ± 3.0[a,c]	93.4 ± 3.0[a,b,c]	*F*(2133) = 5.75, *p* = .00404
Female	92.3 ± 3.1	93.6 ± 2.4	94.5 ± 0.9	
Male	90.8 ± 4.5	93.0 ± 3.6	92.8 ± 3.5	
Subjective sleep quality	67.9 ± 18.2	71.9 ± 18.4	74.9 ± 16.6	*F*(2134.1) = 1.63, *p* = .199
Female	68.5 ± 19.2	71.3 ± 14.2	77.3 ± 15.9	
Male	67.5 ± 17.6	72.6 ± 22.3	73.3 ± 17.3	
Readiness for the day[#]	67.1 ± 15.8[a]	69.1 ± 13.5	76.6 ± 14.2[a]	*F*(2130) = 4.33, *p* = .0151
Female	67.7 ± 15.5	70.2 ± 11.8	75.3 ± 15.8	
Male	66.5 ± 16.3[a]	67.9 ± 15.3	77.5 ± 13.4[a]	
Motivation for the day[#]	64.7 ± 17.0[a]	69.2 ± 13.4	75.8 ± 11.8[a]	*F*(2128.8) = 5.69, *p* = .00428
Female	67.4 ± 14.8	71.4 ± 12.2	73.2 ± 13.5	
Male	62.6 ± 18.5[a]	66.9 ± 14.7	77.8 ± 10.4[a]	

[#]Significant main effect. Mean values with the same superscript are significantly different ($p < .05$). WASO, wake after sleep onset

Bedtimes were considerably later for participants when they engaged in solo masturbation (+35 minutes later) or partnered sex (+26 minutes later) compared to when they did not engage in any sexual activity. Similar to other well-documented presleep behaviors such as hobbies, housework,[28] or electronic media use,[29,30] sexual activity in the form of masturbation or partnered sex delayed participants' bedtime. An interesting observation was that female participants bedtimes were 40 minutes later in the solo masturbation condition when

Table 3
Polysomnographic sleep stage data as a function of sex condition (no sex, solo masturbation, partnered sex)

Characteristic	Sex condition			Statistical outcomes	
	No sex (Mean ± SD) N = 88	Solo masturbation (Mean ± SD) N = 30	Partnered sex (Mean ± SD) N = 33	F (df)	*p*
N1% (%)	7.6 ± 1.5	5.6 ± 1.5	5.8 ± 1.6	*F*(2132.3) = 3.06.22, *p* = .050	
Female	6.4 ± 1.5	5.9 ± 1.5	5.8 ± 1.5		
Male	6.3 ± 1.7	5.1 ± 1.5	5.7 ± 1.7		
N2% (%)	43.8 ± 7.3	36.9 ± 7.9	43.1 ± 7.5	*F*(2131.3) = 1.55, *p* = .215	
Female	47.1 ± 6.4	44.6 ± 8.7	46.5 ± 6.9		
Male	40.9 ± 6.8	39.9 ± 6.6	40.3 ± 6.7		
N3% (%)[#]	23.1 ± 7.2	25.8 ± 7.1	24.3 ± 7.9	*F*(2131.3) = 3.36, *p* = .0376	
Female	20.0 ± 6.2	23.5 ± 5.9	19.9 ± 7.9		
Male	25.7 ± 7.0	28.4 ± 7.6	26.7 ± 6.9		
REM percentage (%)	26.7 ± 5.4	26.2 ± 6.4	28.2 ± 4.9	*F*(2131.6) = 1.37, *p* = .258	
Female	26.4 ± 4.9	26.9 ± 7.5	27.4 ± 6.6		
Male	27.1 ± 5.8	26.5 ± 5.2	28.7 ± 3.7		
N1 duration (min)[#]	27.9 ± 8.8[a]	25.8 ± 4.5[a]	25.9 ± 8.6	*F*(2132.3) = 4.49, *p* = .013	
Female	28.9 ± 9.0	24.6 ± 6.0	28.1 ± 1.5		
Male	27.0 ± 8.7	22.0 ± 8.4	24.9 ± 8.1		
N2 duration (min)[†]	192.3 ± 47.2	175.9 ± 38.4	172.5 ± 39.7	*F*(2131.5) = 2.14, *p* = .122	
Female	211.5 ± 47.2	183.6 ± 36.9	207.1 ± 47.1		
Male	175.9 ± 41.1	167.7 ± 39.5	172.5 ± 39.7		
N3 duration (min)[†]	98.7 ± 28.4	105.8 ± 25.4	106.1 ± 31.3	*F*(2131.3) = 1.96, *p* = .145	
Female	87.2 ± 24.2	96.1 ± 22.7	91.7 ± 30.1		
Male	108.6 ± 28.2	116.2 ± 24.8	114.0 ± 29.6		
REM duration (min)	117.9 ± 30.9	109.8 ± 34.7	117.9 ± 30.6	*F*(2131.7) = 1.93, *p* = .15	
Female	118.5 ± 29.6	108.4 ± 39.7	117.8 ± 32.4		
Male	117.3 ± 32.2	111.3 ± 29.8	117.8 ± 29.2		

[#]Significant main effect. Mean values with the same superscript are significantly different ($p < .05$).
[†]Significant effect of gender. REM, rapid eye movement

compared to their respective no sex condition. There are two plausible explanations for this finding. First, women may need to engage in preparatory behaviors such as creating a comfortable environment and establishing emotional readiness for solo masturbation compared to men.[31,32] Second, there is some evidence to indicate that females have a difference in sexual response and may take longer to achieve an orgasm when compared to males.[33] Wake-up times were similar across conditions. This may be expected as wake-up times are predominantly dictated by impending daily schedules such as work and/or training commitments.[34-36] While delayed bedtimes typically restrict subsequent sleep duration,[37] the findings from the present study revealed no differences in sleep duration across any condition.

This was the first study to objectively examine sleep following three different conditions including no sexual activity, solo masturbation and partnered sex using a portable polysomnographic sleep assessment. Contrary to previous anecdotal reports,[1-3] there were no differences in sleep latency across any of the conditions. Similar findings were reported by Brissette et al[14] where no differences were observed for sleep latencies between solo masturbation and no sexual stimulation conditions. Interestingly, the sleep latencies reported by Brissette et al regardless of sex or no sex condition ranged between 34-38 minutes, compared to the 13-16 minutes reported in the present study. Brissette et al reported the extended sleep latencies were partly due to being conducted in a laboratory environment as well as the experimental condition, whereas our study was conducted in-home.[14]

In the context of the present study, a potential constraint for precisely capturing sleep latency was that participants had to place their DREEM3 headbands on and activate the respective phone application to start recording following solo masturbation or partnered sex. Although the exact mechanisms behind the soporific effect of orgasms is not clear, it is hypothesized that the release of neurohormones such as oxytocin, prolactin, and endorphins said to have relaxing properties have a short time frame to have that facilitatory effect on sleep onset.[5,6] While the sleep latencies reported in this study did not significantly differ, falling asleep in less than 20 minutes is considered optimal sleep behavior.[38] While there was a tendency for reduced sleep latencies following masturbation and partnered sex, it is plausible that the low sample size may have limited the capacity to achieve statistical significance.

With the exception of N1 duration, there were no differences in sleep architecture or sleep duration between the no sex, solo masturbation, and partnered sex conditions. N1 is defined as the lightest stage of sleep where an individuals' eyes are closed but may wake easily, whereas N2 is defined as light sleep where heart rate slows and the body prepares to enter deep sleep.[55] In the present pilot study, N1 duration was highest in the no sex condition compared to the solo masturbation and partnered sex condition. While this difference was statistically significant, the mean difference of 2 minutes offers minimal clinical relevance. While no previous literature exists to compare the sleep outcomes of the partnered sex condition, we can compare the solo masturbation condition of the present study to Brissette et al's (1985) solo masturbation with an orgasm condition. The proportion of time spent in N1 and REM sleep were almost identical across both studies, with a 0.1% difference between studies in the amount of time spent in N1, and a 1% difference in REM sleep. Conversely, the proportion of time spent in N2 and N3 differed somewhat between studies, with participants in the present study spending 11% less time in N2 and 7% more time in N3 than the previous study.[14] However, it is important to note the sleep stages recorded in the present study were consistent with the percentage of sleep stages (e.g., N1: ~5%, N2: ~45%, N3: 25%, REM: ~25%) from the general adult population.[39,40]

In contrast to previous subjective evidence indicating that sexual activity improved subjective sleep quality,[1,2] no differences were observed for subjective sleep quality across any condition. While there was a tendency for higher subjective sleep quality scores following partnered sex, this trend was not statistically significant. This observation was interesting, particularly given that perceptive measures of motivation and readiness for the upcoming day improved considerably following partnered sex compared to no sexual activity. Previous data have documented the positive effects partnered sexual intercourse has on quality of life,[41] cardiovascular health[42] and mood.[43-45] For example, a recent study by Leavitt et al[44] found that when couples engaged in sexual activity, they reported an increased positive affect at work the following day. Likewise, tactile intimacy prior to, and following sexual activity has also been reported to improve relaxation as well as other health outcomes such as blood pressure and heart rate.[4,10,46] It appears reasonable to suggest that sexual activity and/or tactile intimacy has several positive effects on life outcomes.

Consistent with previous data, this study observed REM sleep was longer when participants slept together regardless if they engaged in sexual activity or not.[12] This finding suggests that sexual activity with a partner does not necessarily increase the sleep stage synchrony. However, the findings confirm previous data indicating that REM sleep is especially influenced by cosleeping.[12] Some physiological and social factors may influence the synchronisation of sleep stages such as physical closeness where the couple's movement and breathing patterns may lead to greater alignment to REM sleep.[47] Studies have reported that cosleeping may improve feelings of safety and emotional security.[47]

Strengths and limitations

The present study is the first to examine sleep following sexual activity using objective measures (portable polysomnography). The strength of using polysomnography to examine sexual activity conditions within participants' natural environment, avoids the limitations and constraints of sleep laboratories, and thus, increases ecological validity. While this study expands upon previous work conducted by Brissette et al,[14] some limitations should be acknowledged. Participants completed the experimental manipulations within their natural environment (i.e., at home), and thus, no direct observation was employed by the research team to confirm compliance. This methodology was chosen to avoid a Hawthorne effect whereby participants' knowledge of being observed may modify or influence their behavior.[48] While a strength of this study was the use of objective measures, such as polysomnography, it is possible that participants' subjective responses were influenced by social desirability bias. It is also acknowledged that this study may have an element of self-selection bias such that participants who volunteer for sexual activity research may have higher orgasm frequencies compared to the general population.[49] While there were only two occasions where two participants did not record an orgasm, this enabled the present study to specifically focus on the impact an orgasm has on subsequent sleep behavior. To avoid a delay in sleep onset latency following an orgasm in the solo masturbation condition, participants were instructed to perform this behavior and sleep in a separate room from their partner.[2] This instruction also considered the practical execution and variability of time needed to achieve orgasm via the solo masturbation method.[21] It is possible that given in the solo masturbation condition participants slept alone in a different room, that this may have impacted our findings. The present pilot study was limited to a small number of healthy sleepers. While this population allows us to assess the relationship between sexual activity and sleep without the confounding effects of sleep disorders, health conditions, or age, it is possible that individuals with sleep disorders, health conditions, or older participants may have shown different sleep outcomes following sexual activity. For example, it is possible that prior sleep duration may impact the likelihood of engaging in sexual activities. Some previous

studies have shown that shorter sleep duration and/or sleep disorders often diminish and/or inhibit sexual behavior and function,[50,51] and equally, longer sleep duration increases sexual desire the following day as well as the likelihood of engaging in partnered sexual activity.[52] As such, it may be important for future research to investigate the bidirectional relationship between these two factors. Another limitation of this study is the potential influence of lag effects, where increased sexual desire following better sleep may affect subsequent sleep behaviors.[52] Although participants were instructed on specific nights for engaging in sexual activity, which controlled for timing, this protocol may have restricted natural variations in sexual behavior and their potential influence on sleep. Future studies could consider allowing for more free-living scenarios to capture these natural dynamics.

The sample only included heterosexual couples and did not control for attachment style or relationship satisfaction,[53] it would be valuable for future research to examine the associations between the effects of sexual activity on sleep and attachment style and explore how attachment style may modulate the effects of different sexual activities on sleep. The present study did not control for female menstruation cycle which can also influences sleep.[54] Future studies should look to include some exploration of attachment style, relationship satisfaction and control for menstruation and increase the diversity of the couples to include same gender couples which may provide further insights into gender differences. It is important to acknowledge that the exploration of whether an orgasm during sexual activity is required to produce the observed beneficial effects is warranted such that future studies should investigate sexual activity with and without an orgasm on sleep outcomes. Despite including a larger sample size than that reported by Brissette et al,[14] the present study may have been underpowered to reach statistical significance for some variables. Lastly, utilizing a portable polysomnographic sleep device required participants to activate the start of their recording via a phone application may have disrupted the soporific effect of an orgasm on sleep onset latency.

Conclusion

The main contributions of this study to the field of sexuality and sleep are that this was the first study to objectively examine the influence of sexual activity human sleep using polysomnography in a naturalistic setting (i.e., the home environment). The results emphasize that engaging in sexual activity prior to attempting to sleep does not have any detrimental effect on subsequent sleep quality. Further, the findings support previous subjective evidence indicating sexual activity (e.g., solo masturbation or partnered sexual intercourse) resulting in an orgasm has positive outcomes on subsequent sleep behavior and mood the following day.[1,3] Further, the findings support previous subjective evidence indicating sexual activity resulting in an orgasm has positive outcomes on subsequent sleep behaviour such that participants slept longer and spent less time awake (especially in females) following both solo masturbation and sexual activity with a partner. Future investigations are recommended to increase the sample size of participants, as well as the heterogeneity of the sample to include individuals with sleep disorders, health conditions, and a broader age range. Together such data may offer both the general adult and clinical populations a healthy nonpharmaceutical behavioral approach toward improving nighttime sleep.

Author contributions

ML, GV, MS conceived and conceptualized the study, prepared the initial draft, participated in the writing and preparation of the manuscript and the initial analysis and interpretation of the data; GV, MS, AM, DM, MB, SF participated in the writing and preparation of the manuscript and the interpretation of the data; MB helped with the analysis and interpretation of the data.

Funding

No external funding was received to complete this work.

Declaration of conflicts of interest

The authors report no declarations of interest. The authors alone are responsible for the content and writing of this article.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sleh.2024.11.004.

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